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| 1. Your reference | DB/RED03035/JJ | |
| 2. Patent application number *(The Patent Office will fill in this part)* | 0301660.7 | 24 JAN 2003 |
| 3. Full name, address and postcode of the or of each applicant *(underline all surnames)* | John Redding<br>Fleche Cottage<br>Old Town Hill<br>Lamberhurst, Kent TN3 8EN | |
| Patents ADP number *(if you know it)* | 08569689001 | |
| If the applicant is a corporate body, give the country/state of its incorporation | | |
| 4. Title of the invention | DREDGING, SCOURING & EXCAVATION | |
| 5. Name of your agent *(if you have one)* | BROOKES BATCHELLOR | |
| "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)* | 102-108 CLERKENWELL ROAD<br>LONDON<br>EC1M 5SA | |
| Patents ADP number *(if you know it)* | 08142291001 ✓ | |

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Signature Brookes Batchellor Date 24 January 2003

12. Name and daytime telephone number of person to contact in the United Kingdom DAVID BAILEY 01892 510600

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# APPARATUS FOR SHALLOW-WATER SEDIMENT MANAGEMENT

## BACKGROUND

The present invention relates to an apparatus for carrying out controlled excavation and movement of loose bed material in marine, river, lake and similar underwater environments. The change in bed profile - i.e. removal from one area and deposition in another - achieved using this apparatus comes under the ambit of sediment management. The present apparatus is designed for operation, primarily, in shallow water (1-50m water-depth).

The present apparatus is an development of a means for dredging, scouring and excavation described more particularly in my earlier application GB0227016.3. In this latter document the principle component of the present apparatus, namely the ducted propeller apparatus, is described in more detail together with its various modes of operation. The present apparatus can thus be seen as a vehicle, for bring to bear the operation of the ducted propeller apparatus as described in 0227016.3.

An embodiment will be described which has similarities to the "Wing Dredger" described in US 6125560, in terms of it deployment from a floating vessel by means of suspension wires for the purpose of controlling the direction of the propeller jet(s) relative to the bed. A further similarity exists with the Wing Dredger in the design of the ducted propeller, namely having the propeller at the outlet end of the duct. However, the present invention (i.e.vehicle) differs from the Wing Dredger in being designed specifically for use in shallow water, in being more versatile in terms of single- and multiple-jet operation and in embracing a wholly new and novel approach to propeller jetting.

This new approach recognises and takes advantage of the fact that a free propeller jet (or wake) - that is, a propeller jet unaffected by obstructions (vanes, struts, flow straighteners, etc.) or extended pipework (long ducts, joining or branching ducts, etc.) placed downstream of the propeller - is not a simple thrust means. Rather, it is a complex swirling flow containing a number of vortical flow elements. The benefits of using a raw propeller wake from the point of view of excavation and controlled movement of bed material (sediment management) are described more particularly in 0227016.3. They will only be briefly referred to in the present document.

## SUMMARY

The present invention provides a means for carrying out controlled underwater excavation of sediments and soils, particularly in shallow water (that is - in water depths of less than 50m, down to as little as 1m), with the attendant controlled movement of the excavated material, over long distances, if desired. Controlled, in this respect, refers to the amount and direction of movement of the excavated material and the fact that it is kept close to the bed (i.e. not allowed to penetrate up into the water column). Long-distance, in this respect, means 100m's from the excavation site without the need for associated movement of the apparatus.

The apparatus utilises a ducted propeller system to create a jet of water that is in effect, the raw wake from the propeller. The raw propeller wake comprises a swirling

flow containing a number of vortical flow elements imparted to the flow by the propeller. By manipulating the flow through the duct and at its outlet end, essentially within the apparatus, the character of the jet can be changed significantly. On the one hand, the jet can be made to behave as a simple round jet. This is useful for trenching and side-casting the excavated material to form locally deposited levees on one or both sides of the trench. On the other hand the jet can be forced to greatly expand into a re-circulation cone that applies a strong suction to the bed. This re-circulation flow effect is key to enabling bulk excavation and long-distance movement of bed material, and for excavation in very stiff clays not otherwise amenable to low-pressure water jet excavation.

The re-circulation flow also helps to create the conditions necessary for the formation of a turbidity current flow, which is the mechanism by which long-distance transport of the excavated material is achieved.

In order to be able to operate in very shallow water and yet maintain a certain distance from the bed, the apparatus is designed with intakes on the underside that face downwards. Provided the apparatus is initially filled with water (primed) it will continue to operate partly above the water line since water will siphon through the body of the apparatus and into the propeller duct. Adjustable opening louvre plates over the intakes provide protection from ingress of debris and also provide a means for preventing rotation of the apparatus (countering the propeller torque) when operating in single-jetting mode. More importantly, they also provide a means for controlling the rate of water flow through the propeller duct.

The apparatus is of simple box-like construction, being made from steel plate, with one ducted propeller unit per apparatus. The design is such that two or more units can be easily coupled together in different configurations for multiple jetting operations.

The propeller is driven by a high-pressure hydraulic motor, which is incorporated into the duct. The use of an hydraulic motor is an integral part of the overall design of the apparatus, since it enables a very compact and light-weight construction and also provides for variable speed and direction control over propeller rotation.

Importantly, the present invention seeks to provide a means for bringing to bear the different behavioural characteristics of a raw propeller jet (as described in 0227016.3) for the purpose of bed excavation and movement of the excavated material.

The present invention is seeks to enable excavation and movement of bed material to be carried out in very shallow water.

The present invention yet further seeks to provide an apparatus that can be suspended from a support vessel and operated as a single jetting unit or in multi-unit configurations.

## BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and advantages are hereinafter set forth and described with reference to the following drawings, wherein:

Figure 1 shows an oblique underside view of the exterior of an embodiment of an apparatus in accordance with the present invention.

Figure 2 shows an oblique topside view of the exterior of the apparatus.

Figure 3 shows sectional views through the apparatus. Figure 3a is a vertical section on the long axis, and Figure 3b is a horizontal section at mid-level.

Figure 4 shows sectional views through one of the intakes to illustrate the louvre plates and the mechanism controlling the degree of opening of these plates. Figure 4a shows the louvre plates fully open (against the bar stop), Figure 4b shows the louvre plates half open (against the bar stop), and Figure 4c shows the louvre plates shut (with no flow through the intakes).

Figure 5 shows, in diagrammatic form, the water-flow circulation through the apparatus depending on the direction of rotation of the propeller. Figures 5a shows normal flow jetting, and Figure 5b shows reverse flow filling (priming).

Figure 6 shows various ways in which the apparatus can be suspended from a vessel and various ways in which multiple units can be coupled together.

Figure 7 shows a modification to the duct and propeller that can be used to increase the axial velocity of the jet.

Figure 8 shows two modifications to the outlet and inlet of the duct to force the development of a re-circulation flow and to increase the turbulence intensity of the jet.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Figures 1 and 2 show an embodiment of the apparatus of the present invention to comprise a rectangular body or tank 10 of generally light-weight construction; steel plate being a suitable construction material. The dimensions of the tank, as shown, are in the ratio: length 3; width 2; height 1.5. It is envisaged that these dimensions would be represented by metres, however the overall size of the tank is not critical to the operation of the apparatus and may be any convenient size or, indeed, shape

To provide added stiffness to the construction, as shown in Figures 1 and 2, the abutting long side plates 12 and top plate 13 and bottom plate 14, are formed by angled plates 15. This has the added benefit that on the inside of the tank the lower sides slope inwards creating a partial hopper effect. Material carried in-board in suspension with the intake flow (see Figure 5a) that might otherwise settle inside the tank in the angle between the sides and base is encouraged to slip back towards the intake and so be more likely to be maintained in suspension through the apparatus.

Reference to Figure 3 shows that the hopper effect is completed by angled fillets 47 placed along the contact between the end plates 16 and the bottom plate 14 and between the bottom plate 14 and the central bulkhead plate 45.

Various attachment points are provided on the outside of the tank, as indicated in Figures 1 and 2. There are four corner attachment points 17 at each end, formed by the projections of the end plates 16, and four centre attachment points 18, which comprise triangular plates 19 welded to the angle plates 15. The position and orientation of the triangular plates 19 correspond internally to the bulkhead plate 45. Smaller triangular fillet plates 20 provide added lateral stiffness to each of the support points.

Referring to Figure 2, it can be seen that two hatch-covers 22 are provided on top of the tank that give access, via associated openings, to the inside of the tank. These hatch covers are of conventional construction, but are designed specifically to provide an air-tight seal to the tank when fully closed. Also on the top of the tank, are two grab rails 23 that run along the outer long edge of the top plate 13. These are formed of steel pipe and are attached at their two ends and at intermediate locations in such a way that there is communication between the inside of the tank and the bore of the pipes. Set onto the top of the grab rail pipes towards each end, are short, internally threaded, spigot pipes 24, into which non-return valves (not shown) can be screwed. The non-return valves are designed to allow egress from the tank of air and water, but not ingress. Their function and operation will be described later.

Also on the top of the tank and attached to the top plate 13 by means of multiple bolts, is a circular plate 25. Circular plate 25, when removed, gives access to the inside of the tank for the purpose of removing the propeller duct unit. The circular opening in the top plate 13 that is covered by circular plate 25 is thus made slightly larger than the outermost diameter of the propeller duct. Circular plate 25 is fitted with a rubber gasket designed to effect an air-tight seal.

Also formed centrally in circular plate 25 are three circular openings set out in triangular fashion. These provide penetration for the three hydraulic hoses that connect to the motor (two high-pressure power hoses and one low-pressure casing drain hose). Split flanges 26, formed of rigid plastic, and bolted to circular plate 25 over each opening, encircle each hose and provide an air-tight seal where the hoses enter the tank. Split flanges 26 also serve to secure the hoses at the point of entry to the tank and prevent any risk of chaffing against metal edges.

Completing the appurtenances on the top of the tank, as shown in Figure 2, is a small detachable stool-like structure 27, consisting of a circular ring supported by means of struts at a fixed distance above the top plate. The hydraulic hoses pass through the ring and are loosely supported in such a way that over-bending, or kinking, of the hoses at the point of entry into the tank is prevented.

Referring to Figure 1, the circular outlet 28 of the propeller duct can be seen to be centrally located on the underside of the tank. Also the position of the propeller 29, just inboard of the duct opening, can be clearly seen. It should be noted that there are no rigid obstructions (vanes, struts or other protusions) in way of the propeller jet, within or below the outlet end of the duct.

Located either side of the propeller duct outlet 28, are two water intakes 30. These are rectangular in shape and are of such a size that one on its own would provide for

unhindered flow of water into the propeller duct inlet, when the propeller motor is operating at full power. Attached to the bottom plate 14 and extending vertically over each opening are three thick metal grill plates 31. These are designed to prevent large items of debris, or obstructions sticking up from the seabed, from penetrating the intakes. They are also designed to take the weight of the apparatus when the latter is placed on-deck or onto a hardstanding surface. If the apparatus were to be placed on a soft surface, wooden sleepers would need to be used to prevent the grill plates from penetrating into the surface.

Figure 1 also shows that immediately inboard of the intakes 30 are multiple louvre plates 32, which extend across each intake. These are designed to prevent ingress of smaller debris that might otherwise pass between the thick metal grill plates 31. Each louvre plate has a hinge attachment to the bottom of the tank at either end, such that each plate is free to rotate about a hinge-line coincident with the bottom edge of the plate. A detail of this hinge attachment arrangement is shown in Figure 4.

Referring to Figure 4 it can be seen when the louvre plates are lying flat (Figure 4c), the intakes are effectively closed, save for minor leakage at the edges of the plates. This leakage is useful in that during reverse circulation flow (see below) it helps to flush out any residual silt that may have collected in the bottom of the tank. When the louvre plates are pointing nearly vertically upwards (Figure 4a), the intakes are fully open (unhindered flow to the propeller duct). When no water is being drawn through the intakes, self-weight causes the plates to fall shut and adopt the imbricate arrangement shown in Figure 4c.

A simple bar stop 33, supported at either end on pillars 34, allows adjustment of the amount of opening of the louvre plates. Each pillar 34 has a series of holes drilled into it to allow the bar stop to be secured at different heights above the base of the tank. As presently designed, adjustment of the amount of louvre plate opening has to be by man access through the hatch covers. It is envisaged that in due course a remotely operated louvre adjustment mechanism will be adopted.

It should be noted, also, that the louvre plates are set in such a way that they face in opposite direction over each intake. While this is of little consequence when the plates are fully closed or fully open, it will be appreciated that with the louvre plates at intermediate positions (Figure 4b), water entering the intake will be forced to do so at an angle, which will be opposed on the two sides. This opposed deflection of the intake water flow imparts a turning moment to the apparatus, which can conveniently be used to counter any tendency for rotation in the opposite direction induced by the propeller. It will be appreciated that the direction of angling of the louvre plates has to be co-ordinated with the direction of rotation of the propeller.

Lastly, in referring to Figure 1, it should be noted that surrounding the outlet end of the propeller duct is a flange plate 35 directly welded to the bottom plate 14. This flange plate 35 has a series of tapped holes drilled into it, the purpose of which will become apparent late.

Reference to Figure 3a shows the inside of the tank in vertical section, for the purpose of illustrating, particularly, the disposition of the propeller duct 36 and motor 37. The propeller duct 36 can be seen to have a vertical length approximately 2/3$^{rd}$ the height

of the tank, and to have a bellmouth 38 at the top (inlet end) to facilitate the inflow of water. The motor 37 is axially positioned in the duct with its shaft (not seen) facing downwards and the high-pressure hydraulic fluid ports (for attachment of the two high-pressure hoses 38) facing upwards. A side tap on the motor (not shown) provides attachment for the casing drain hose 39 (see Figure 2).

The motor is supported axially within the duct by means of a collar 40 to which the motor is secured by a ring of axial bolts, and the collar is secured to the inside of the duct by means of angled fin plates 41. The fin plates are vertically set in order to present a limited surface area to the direction of flow and their edges are also chamfered to further minimise flow obstruction. There are five supporting fin plates 41, equally spaced, this number being purposely chosen to provide both a rigid axial support to the motor and an non-equal or non-multiple of the propeller blade number (four-bladed propeller); the latter being good engineering practise in terms of ducted propeller design.

The motor can be seen to taper downward at its front end, and to make a smooth transition with the hub of the propeller 29. This smooth profile of the motor and propeller hub is also match by the shape of the duct, giving a uniform width of annulus between the motor and the duct.

The duct, complete with motor, is detachable from the tank and can be removed through the top of the tank. The duct has three rings 42 welded around its outer circumference, which are designed primarily to maintain the ovality of the duct during and following fabrication. The uppermost ring also gives added stiffness to the duct at the point of fixity of the angled motor support fin plates, while the lowermost ring also acts as a seating flange when the duct is installed into the tank. This lower ring has two holes drilled into it that act as stabbing guides for pegs (43 indicates the locations) that stick up from a landing flange 44 on the bottom of the tank. The two upper rings also have holes drilled in them to enable the duct to be rigidly secured on either side to the central vertical bulkhead plate 45. Angled brackets 46, in pairs, provide the means for bolting the propeller duct to the bulkhead plate.

Also visible in Figure 3 are the fillets 47, designed to complete the hopper-like form of the tank base around each intake, and referred to earlier. The fillets may be of any suitable material, such as concrete, and may be removable or cast in situ.

Lastly, in referring to Figure 3, it should be noted that although the bulkhead plate 45 only extends inwards as far as the propeller duct, it stretches the full height of the tank; and thus effectively divides the tank into two separate compartments below the top level of the propeller duct. Directly over the top of the propeller duct, however, there is free communication between the two halves of the tank.

The workings of the apparatus will now be briefly described by reference to Figure 5. In the first instance, it will be assumed that the apparatus is being operated in sufficient depth of water that the siphonic action is not required.

Figure 5a shows that when the propeller is rotating, such as to produce a downward jet of water, water is drawn through the intakes 30, circulates through each side of the tank, enters the top of the propeller duct through the bellmouth inlet 38, travels

through the duct 36 and is forced out of the duct outlet 28. The reduction in pressure inside the tank caused by the rotation of the propeller (acting like an axial flow pump) causes the louvre plates 32 to open as far as the bar stop 33 will allow. Water is thus sucked into the tank at a rate determined by the speed of rotation of the propeller and the degree of opening of the louvres.

Since all other points of ingress for water into the tank are sealed, the louvre plates provide an effective means for regulating (i.e. reducing) the flow of water through the propeller duct for any given speed of rotation of the propeller. The main reason for wanting to reduce the flow of water through the propeller duct is that with a reduced flow rate, the propeller imparts relatively more energy to the water, the axial velocity of the jet is also reduced compared to its swirl velocity and the vortical flow elements within the jet become more energised. In propeller design parlance, this reduction in flow through the propeller disc is referred to as decreasing the propeller advance coefficient (J). One of the significant effects of this (as described more particularly in 0227016.3) is that it makes the jet's central hub vortex more susceptible to breakdown, with the attendant formation of a re-circulation flow.

Hub vortex breakdown and re-circulation flow are discussed later in relation to various attachments to the apparatus that are designed to promote this particular phenomenon.

When starting the apparatus in very shallow water an initial priming action may be necessary, which is illustrated in Figure 5b. The propeller is initially rotated at slow to moderate speed in a reverse direction, which has the effect of forcing water into the tank through the propeller duct. The louvre plates act as (leaky) one-way valves preventing wholesale egress of water through the intakes. Air and then water are thus forced out of the top of the tank through the four non-return valve spigot holes 24. Once the tank has been filled with water and purged of air (indicated by spouts of water from the holes 24) the motor rotation is quickly reversed to begin normal jetting operations, as shown in Figure 5a. This priming action can also be used as an effective way of cleaning (back-washing) residual material from the bottom of the tank, material being washed out in the leakage flow that occurs underneath the louvre plates on either side of each intake (see Figure 4c).

Normal jetting once established can continue even with much of the tank out of the water, because the propeller creates sufficient suction head for water to siphon into the propeller duct. The fact that the intakes are placed on the bottom of the tank also means that there is less likelihood of air being sucked in via a vortex. Clearly, for this siphonic action to work effectively the emergent top of the tank has to be fully air-tight.

For most operations, where simple jetting of the bed is required, the apparatus would be suspended by one or two pairs of wires from a crane, or A-frame, mounted on a support vessel. Figure 6 shows a number of possible support options, together with various ways in which several single-jet units can be coupled together to form multiple units. In Figure 6a a single unit is shown suspended by two wires 48. Loops of chain 49 with their ends attached to the upper corner points 17 provide a means for adjusting the roll and pitch of the apparatus. By shackling the wires to links on one or other side of the centre point of each loop, forward or backward pitch can be

introduced. By adjusting the length of each chain independently, sideways roll can be effected. In this respect, operation similar to that described in 6125,560 is achieved.

Single unit operation is intended primarily for pipeline (or cable) jetting work. For instance, where a pipeline laid on the seabed is required to be lowered below the bed surface for the purpose of increased protection. The ability to tilt the apparatus sideways is important, since by directing the tilted jet just under the pipe as the unit traverses along and adjacent to the line of the pipe, material can be displaced to the far side of the pipe to form a levee stockpile. The same material can then be used to backfill the trench by jetting from the opposite side with the jet tilted towards the stockpile and the trench. Note that a significant advantage of this jetting equipment over conventional ploughing equipment is that there is no mechanical contact with the pipe.

In Figure 6b two units are shown coupled together in-line and suspended in similar fashion, but with the chains 49 attached to the four upper centre attachment points 18. Because the separation of the wires and the attachment arrangement of the chains is identical to that for the single unit (shown in Figure 6a) a double unit can be operated from the same vessel in exactly the same way as a single unit. It is a also a very simple matter to couple two units together in-line, by means of four high-tensile bolts passing through the four common corner attachment point holes 17.

A double in-line unit (or indeed a triple in-line unit, as shown in Figure 6c) would be used primarily for bulk movement of material. This might include pre-sweeping of a corridor through sandwaves for the purpose of preparing a smoothed profile for laying a large diameter pipeline, or it might include removal of material from shoal areas in a navigation channel. Either way, material has typically to be removed in large quantities to an agreed level, and in the latter case the excavated material has to be deposited below the navigation depth. By operating two or more units in-line (as shown in Figure 6) the jets act in concert to remove a swathe of material. Typically, the units would be tilted (pitched) in the direction of forward travel so that material is displaced in this direction. No sideways roll would be used, as the objective is to create a level surface.

To enhance the rate of bulk excavation and the ability to move the material long distances with these multiple in-line configurations, a re-circulation jetting mode would be used, as discussed shortly.

Finally, Figure 6d shows two units coupled together in saddle fashion, metal struts 50 being used to cross-connect adjacent upper and lower attachment points (17 and 18) and achieve the desired angle of convergence of the jets. A similar suspension arrangement is used, as in the other sketches. Such a converging jet arrangement would be used, for instance, where increased jetting energy was required for lowering a pipeline (or possibly exhuming an existing buried pipeline). The focussing of the two jets means that excavation energy is concentrated at the point of intersection of the two jets.

Figure 7 shows a modification to the duct and propeller that can be used to increase the axial velocity of the jet, while at the same time reducing its diameter. Such a jet might be used, for instance, for carrying out enhanced trenching operations (i.e.

cutting deep narrow slots for the purposes of installing cables, small diameter pipelines or umbilicals). The normal four-blade Kaplan propeller 29 would be removed and replaced by an Achimedes screw-type impeller 51, as used in jet pumps. A duct constriction 52 would also be used, bolted to the bottom flange plate 35.

Figure 8 shows a second modification to the duct outlet, which involves a flared nozzle (wide-angle bellmouth diffuser) attachment 53. This is also bolted in place to the bottom flange 35. The flared nozzle has the effect of forcing the jet to expand, in so doing its velocity is reduced and its stagnation pressure is increased. The result is that the hub vortex, created by the normal four-blade propeller, experiences breakdown with the formation of a re-circulation flow field that supplants the normal round jet. The effect and its physical justification are described in more detail in 0227016.3. Suffice it to say here, that the effect results in a significantly enhanced ability for rapid excavation in a wide range of loose bed materials. This includes an ability to excavate in stiff clays, albeit at a slower rate, which are otherwise not amenable to excavation by low-pressure water jets, and a capability to transport the excavated material over long distances (100m's) by means of a turbidity current transport mechanism.

It should be noted that the flared nozzle modification does not constitute an obstruction placed in way of the propeller jet, since its internal diameter is either equal to (at the attachment end) or greater than that of the propeller duct outlet.

To augment the turbidity current transport mechanism a second modification is shown in Figure 8, which comprises a simple wire mesh grid 54 placed over the bellmouth inlet of the propeller duct. This has the effect of enhancing the overall turbulence content of the flow through the duct and in within the emerging jet, while at the same time slightly reducing the axial flow through the duct. The wire mesh grid would thus be used in conjunction with the louvre plates to regulate the flow through the duct. Enhanced jet turbulence provides an important means for ensuring long distance transport of sand-size material, as discussed in 0227016.3.

The following statements set out some of the preferred features and advantages of the apparatus of the present invention:

1. The improved ability (compared to 6,125,560) to operate in shallow water for the purposes of carrying out underwater jetting excavation and movement of bed material. Said ability being achieved by means of a short propeller duct arrangement, housing the propeller duct and duct inlet inside an air-tight tank, having the primary water intakes on the underside of the tank and being able to carry out an initial priming operation wherein the propeller is reversed to induce filling of the tank.
2. The improved ability and greater versatility to operate in single- and multiple-jetting configurations, by coupling single jetting units together.
3. The improved ability to control and regulate the flow of water through the duct and where the flow emerges from the duct for the purpose of exercising control over the subsequent behaviour of the jet. Said jet behaviour being either that of a simple round jet or of a much expanded re-circulation flow. Said behaviour being controlled by adjustable louvre plates over the primary water intakes, by a wire mesh grid placed over the propeller duct inlet and by a wide-angle diffuser

nozzle placed over the propeller duct outlet. Any of these modifications may be used singly or in combination.

4. The improved ability to increase the axial velocity and reduce the diameter of the jet for the purposes of narrow/deep trench excavation. Said improvement being achieved by replacing the normal 4-bladed Kaplan propeller with a jet pump type impeller and by reducing the diameter of the outlet nozzle.
5. The ability, stemming from numbered paragraph 3, to carry out very rapid excavation in a wide range of loose bed materials and the attendant directional movement of the excavated material over long distances (100m's). Said movement being by means of a turbidity current flow transport mechanism and occurring close to the bed so that excavated material is prevented from rising up into the water column. Said movement also being generally downhill so that that material from shoal areas is automatically transport into deeper water.
6. The ability, also stemming from numbered paragraph 3, to carry out excavation (albeit at a slower rate) in stiff clay materials that are otherwise not amenable to excavation by means of low-pressure water jetting.
7. The ability, equal with 6,125,560 to operate the apparatus from a support vessel by means of a wire suspension system wherein the attitude of the apparatus can be adjusted in terms of both pitch and roll. Said capability being used for the purpose of sideways displacement of material (such as for pipeline jetting) and for forward displacement of material (such as for pre-sweeping and sediment management operations).
8. The added benefit, further to numbered paragraph 3, wherein the said louvre plates and the wire mesh grid also provide a means for preventing access of debris into the propeller duct.
9. The added benefit, further to numbered paragraph 3 and numbered paragraph 8, wherein the said louvre plates when half open also provide a means for preventing rotation of the apparatus by countering the turning moment induced by the propeller.
10. The added benefit, further to numbered paragraph 8, wherein thick grill plates over the intakes protect from ingress of coarse debris and penetration of seabed obstructions. Said grill plates also provide a means for supporting the apparatus when not in use.
11. A simply body shape that is strong, light-weight and functional (in terms of forming an air-tight sealed tank), that is in effect is self-cleaning by having a hopper-like base form, that has attachment points strategically placed to enable the body to be suspended from wires and chains and coupled to like bodies in different configurations for the purpose of multiple jetting.
12. A simple means for installing and removing the propeller duct, i.e. for maintenance purposes, and to enable said propeller duct to be used in other propeller jetting embodiments.
13. The added benefit, further to the self-cleaning ability noted in numbered paragraph 11, of using the priming action, noted in numbered paragraph 1, as a further means for cleaning (backwashing) the inside of the tank.

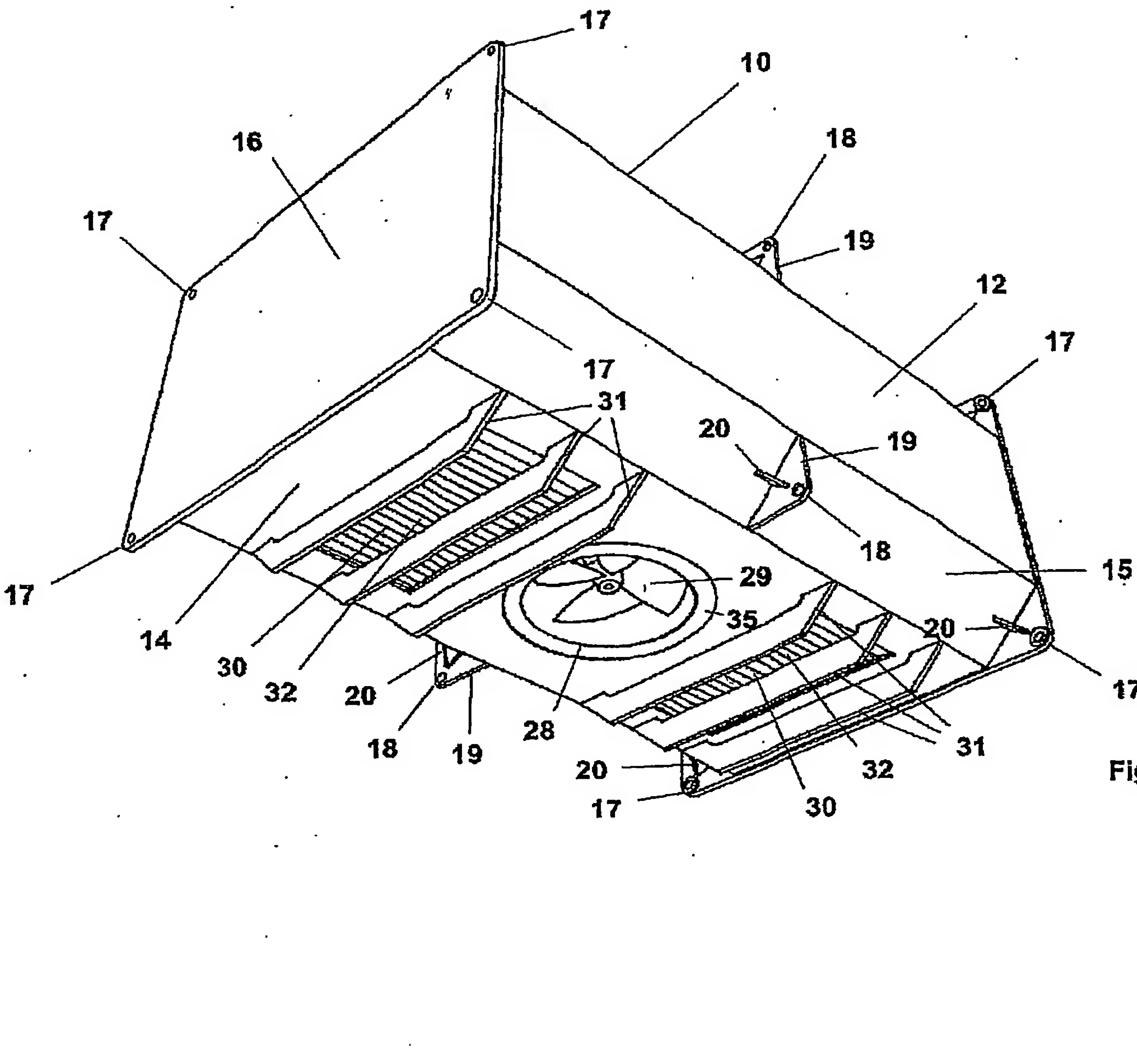


Figure 1

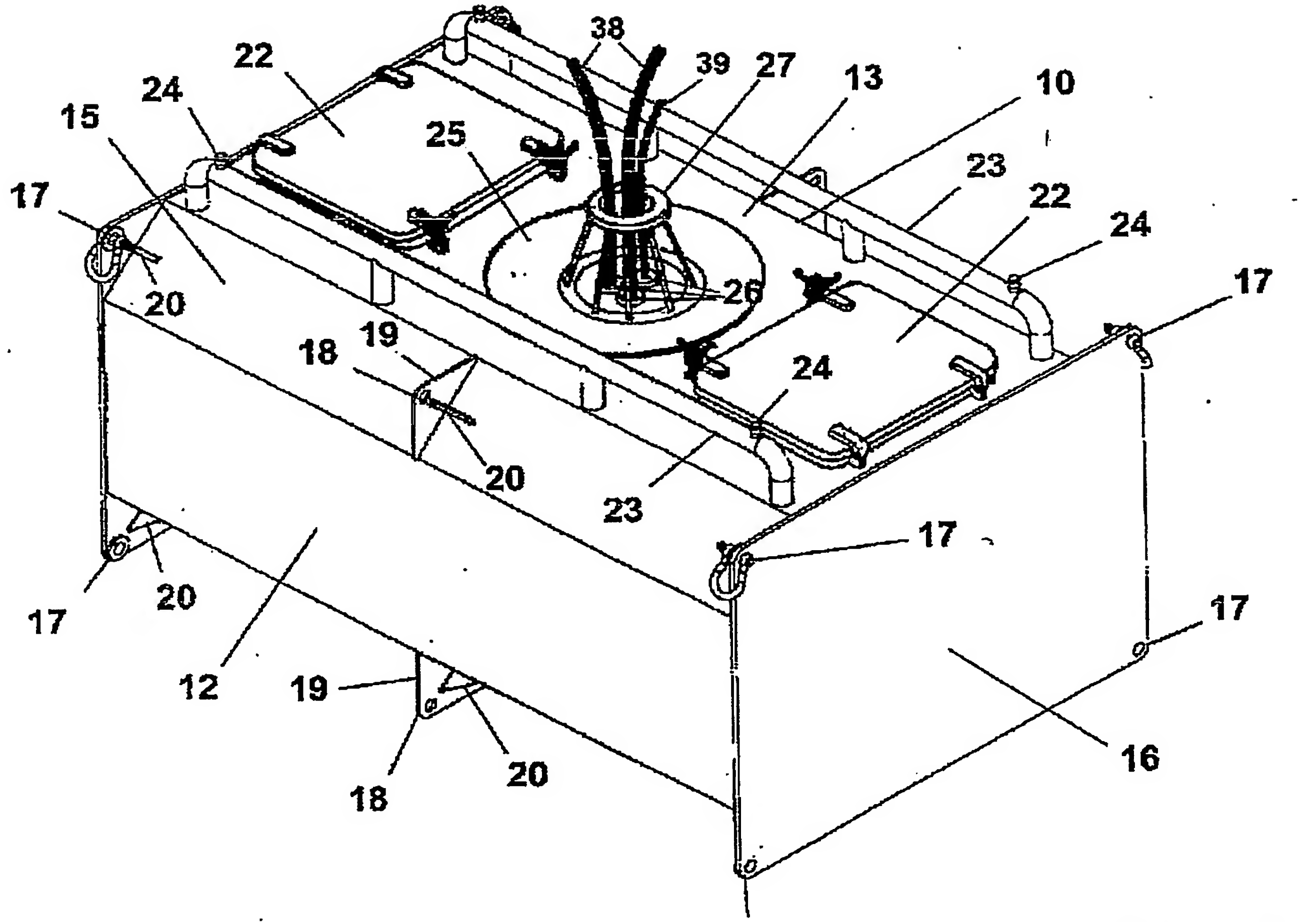
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Figure 2

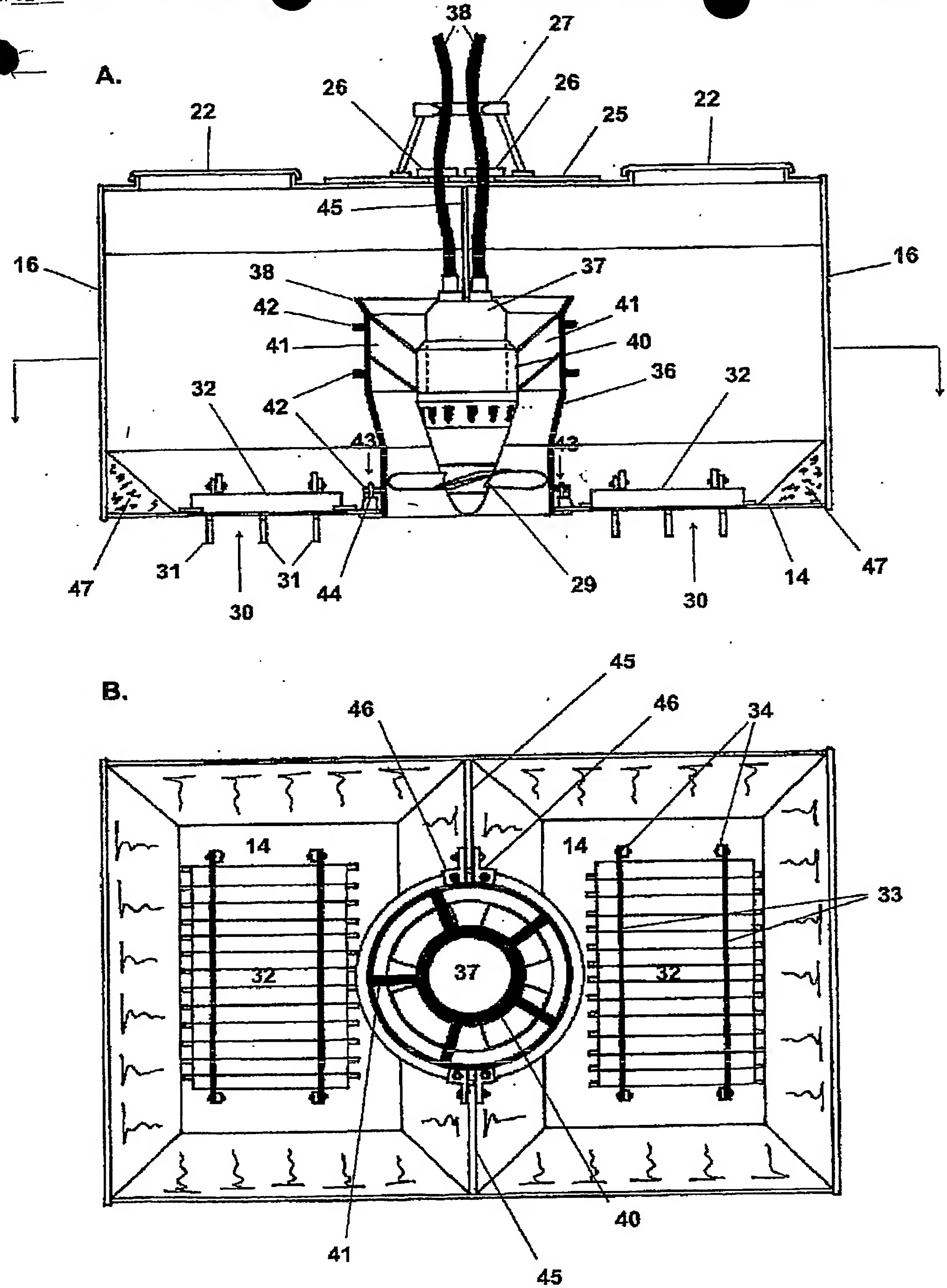
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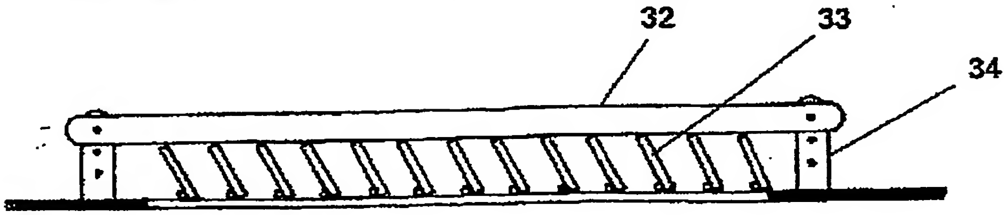
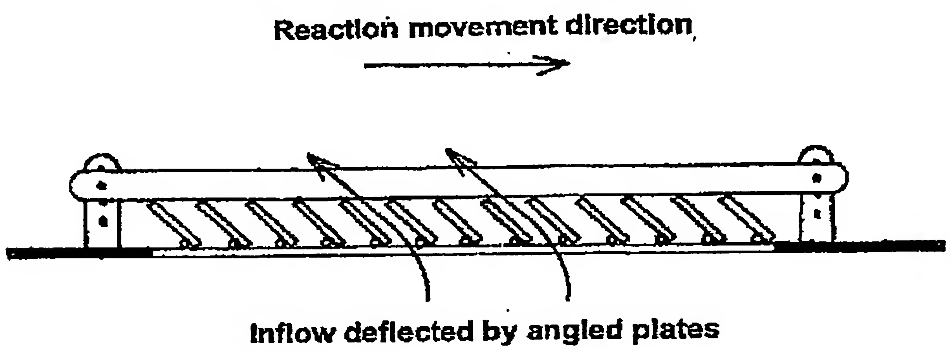
Figure 3

A. Louvre plates fully open (against bar stop)




B. Louvre plates half open (against bar stop)




C. Louvre plates fully closed (due to self weight)

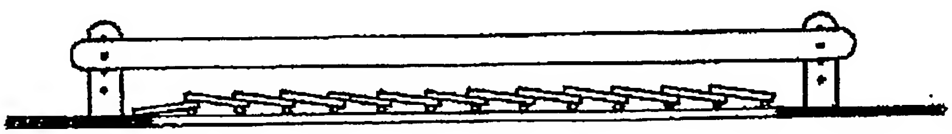
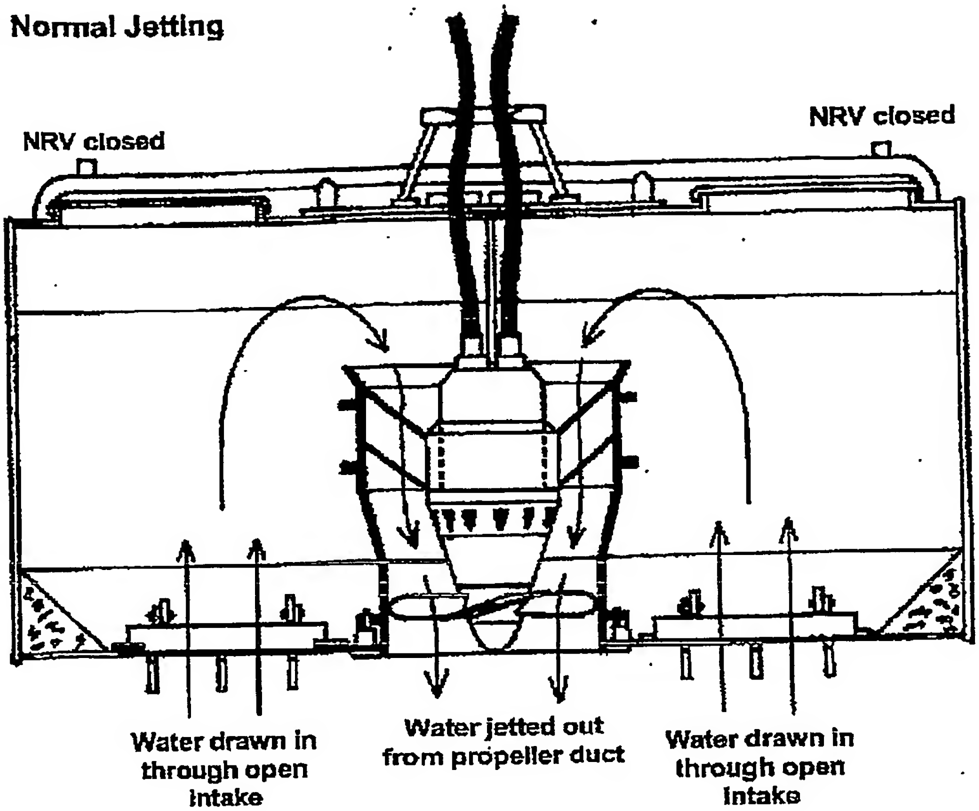


Figure 4

A. Normal Jetting




B. Priming

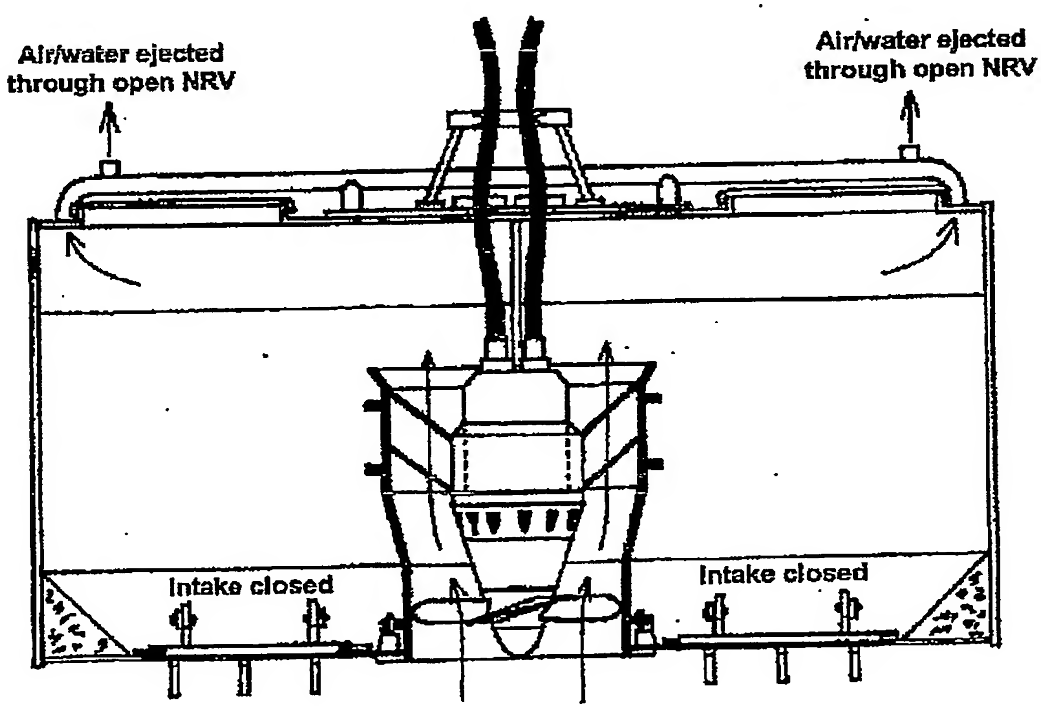



Figure 5

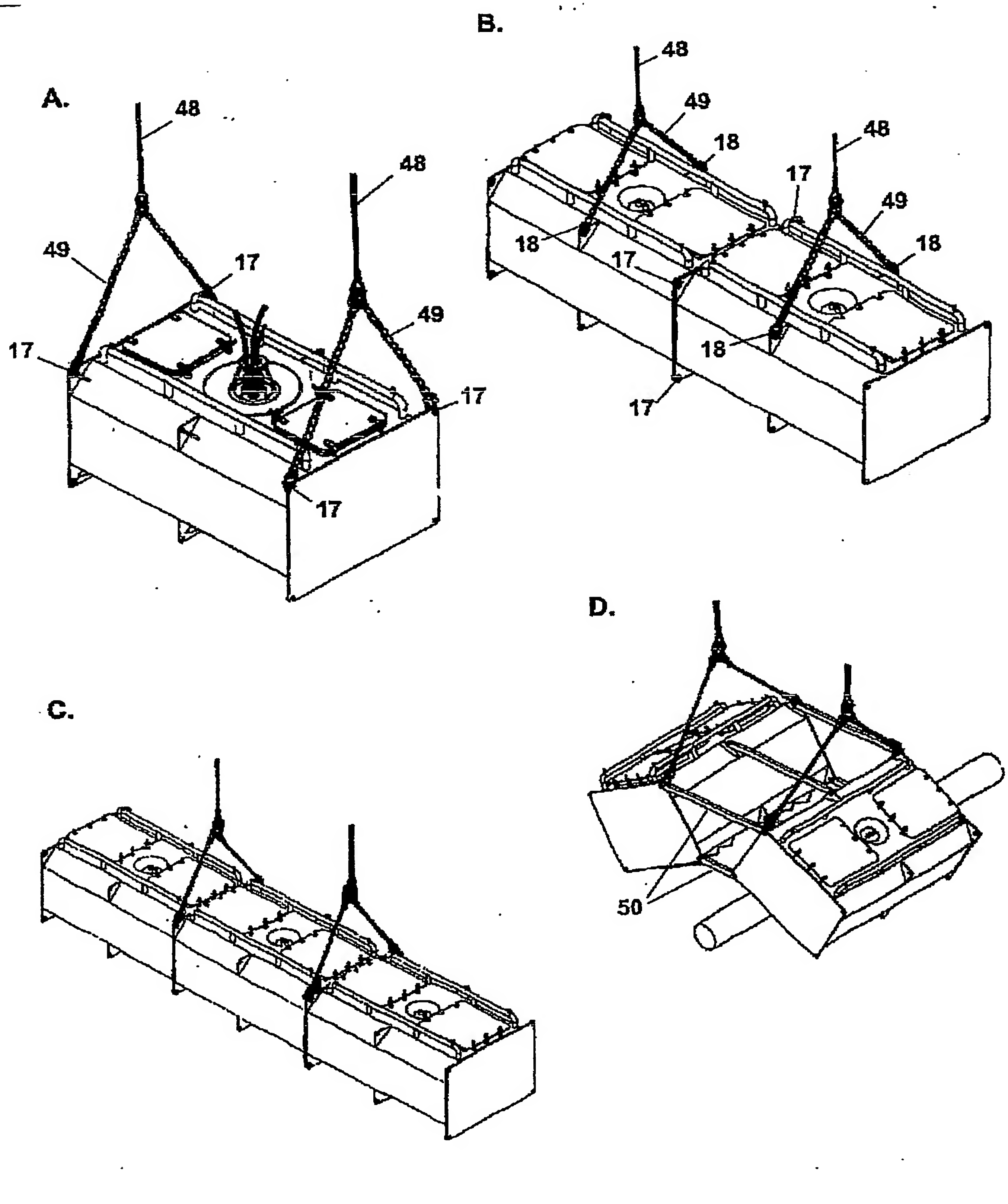



Figure 6

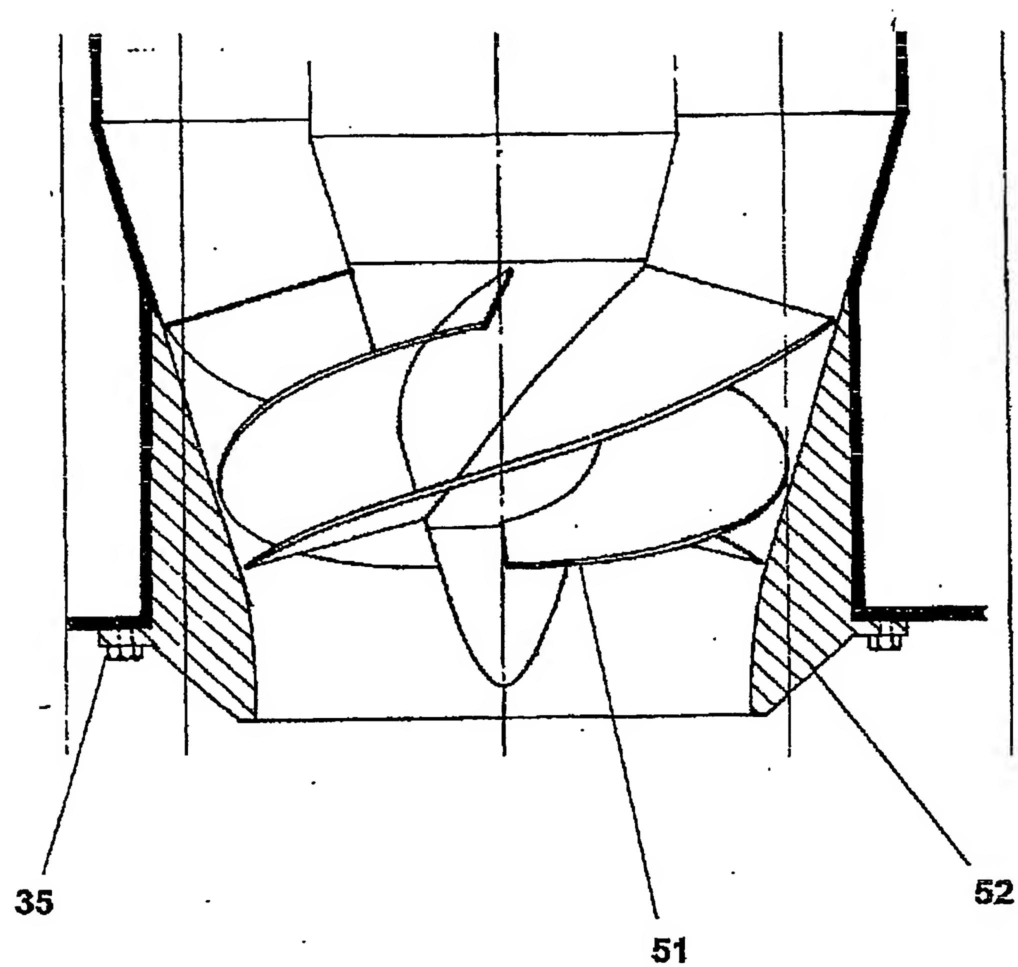



Figure 7

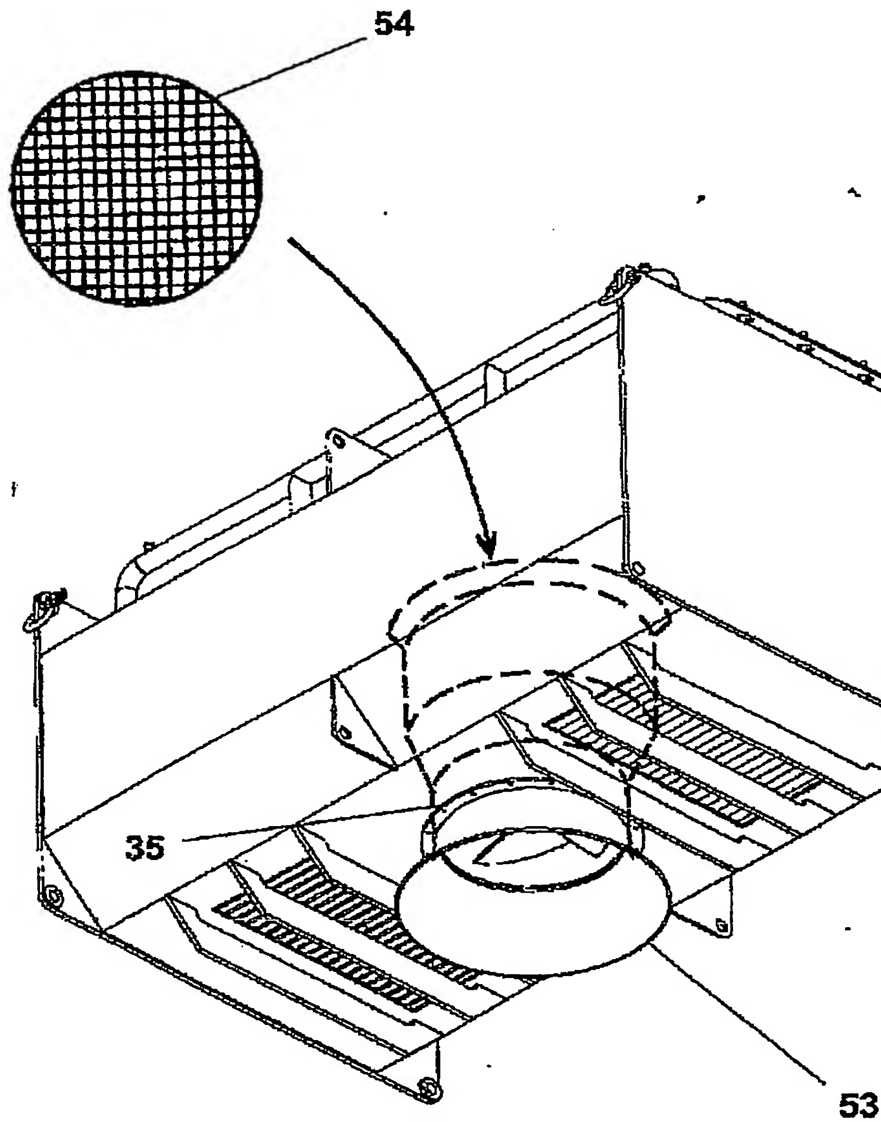



Figure 8